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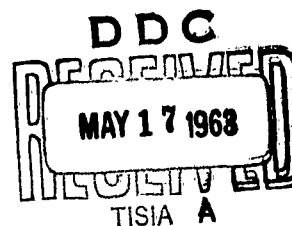
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THE MODULUS OF POLYETHYLENE

by

A. V. Tobolsky and V. D. Gupta



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## The Modulus of Polyethylene

In a previous article in this journal, we simultaneously measured shear modulus, density, and crystallinity for linear polyethylenes as a function of temperature in samples subjected to various annealing procedures.

At sufficiently high temperatures, the degree of amorphicity becomes appreciable and the modulus becomes lower than  $7 \times 10^8$  dynes/cm<sup>2</sup>. Under these conditions one can interpret the modulus as a rubber elasticity modulus. In the sample, under these conditions, the crystallites have a dual role: they act as crosslinks and also as filler particles. An equation has been proposed for the shear modulus:

$$1. G = \frac{(1-Q)dkT}{\bar{r}m} (1+2.5Q+14.1Q^2)$$

In equation (1)  $Q$  is the fractional crystallinity,  $d$  is the density,  $m$  is the molecular mass of the repeating link in the chain ( $\text{CH}_2$  in this case,)  $k$  is Boltzmann's constant,  $T$  is the absolute temperature, and  $\bar{r}$  is the average number of  $\text{CH}_2$  units in an amorphous sequence of the polymer chain connecting two crystallites. The term in parenthesis on the right hand side is a correction for the "filler effect."

Data obtained in reference (1) on  $Q$ ,  $d$  and  $G$  at various temperatures enable us to compute  $\bar{r}$ , a quantity which should be of use in characterizing crystalline polymers.

We believe that it is permissible to apply equation (1) based on rubber elasticity theory for values of  $G$  less than  $7 \times 10^8$  dynes/cm<sup>2</sup> and for values of  $\bar{r}$  equal to or greater than ten. This is suggested by our systematic studies of highly crosslinked polymers<sup>3</sup>.

Table I shows the data for  $T$ ,  $d$ ,  $Q$ , and  $G$  for sample (No. 491)  
 $\left( \bar{M}_v = 2.8 \times 10^5 \right)$  of reference (1) together with the values of  $\bar{r}$  computed by equation (1).

It would, of course, be of great interest if other physical methods for measuring  $\bar{r}$  could be developed.

Table I

Linear Polyethylene

Temperature °C	Density	Crystallinity	Modulus (dynes/cm <sup>2</sup> )	$\bar{r}$
115	0.918	0.76	$6.53 \times 10^8$	10.0
120	0.912	0.70	$4.95 \times 10^8$	14.9
125	0.903	0.67	$3.37 \times 10^8$	22.6
130	0.892	0.51	$7.8 \times 10^7$	70.6
133	0.795	0.30	$6.9 \times 10^7$	95.8

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